Effect of Yoga Therapy on Neuromuscular and Cardiovascular Functions and Reduction of Autism Severity in Children with Autism Spectrum Disorder: A Randomized Controlled Trial

A synopsis of the thesis for the award of Degree of
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1. INTRODUCTION

Autism spectrum disorder(ASD) is a neurodevelopmental disorder that affects social skills, behaviour, speech and nonverbal communication.[1] Recent studies show that approximately 24 percent of individuals with ASD have intellectual disability, 23 percent have low levels of cognitive functioning and the rest have minimum level of intellectual ability but do not fall in the intellectual disability range.[2,3] National Health Interview Survey based studies showed that prevalence rate of ASD had increased from 1.25% to 2.24%, and other developmental delay disorders declined from 4.84% to 3.57% in the year 2014.[4] More than 2,160,000 individuals, i.e., 1 in 500 or 0.20% of the population in 2016 in India (Fig. 1) and globally 61.9/10,000 individuals in 2012[5] is its estimated prevalence. In 2020, the Centers for Disease Control and Prevention reported the prevalence rate as 1/54 with the ratio of boys to girls as 4:1 in children with ASD in U.S.[2]

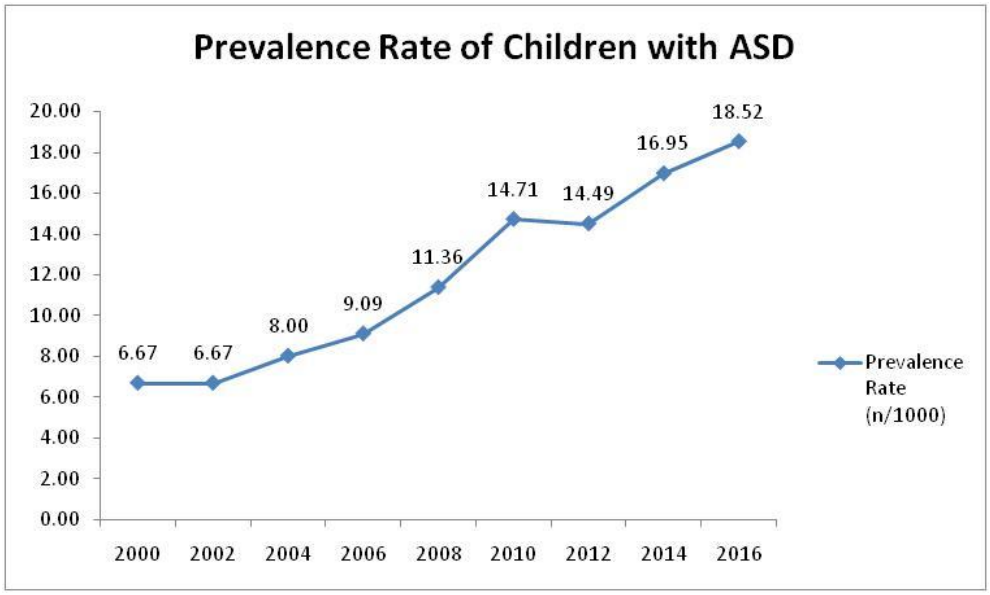

Figure 1: Increasing order in the prevalence rate of children with ASD.

1.1. AUTISM AND MENTAL ILLNESS

Autism does not comply with mental illness since it doesn't interfere with cognitive function alone but impacts a person's ability to learn, or to understand certain thoughts and may cause physical changes whereas mental illness is associated with mental distress

and problems with social functioning that involve changes in thinking, behaviour, emotion and may cause hallucinations and delusions.[6]

1.2. ETIOPATHOGENESIS OF ASD

Several studies found that the characteristics of qualitatively impaired communication, social interaction, and restricted range of activities and interests can be linked with immune-mediated mechanism in children with ASD; between prenatal infection – driven inflammation; and with preterm born children who usually have the highest risk of exposure to perinatal infection on the central nervous system but it is not clear and there is no scientific evidence how these interconnect towards the development of ASD in the offspring.[7] In contrast, the classical yogic text, Thirumandiram, explains its etiopathogenesis as stress during copulation, preconception and pregnancy that results in the development of ASD in the offspring.[8–10]

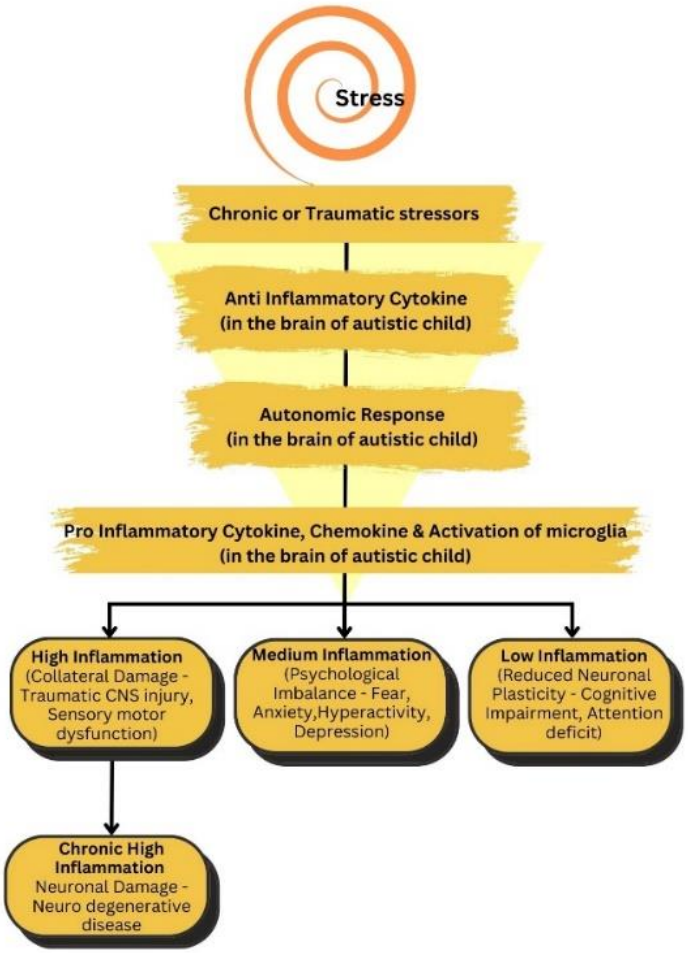
Stress
Chronic or Traumatic stressors
Anti Inflammatory Cytokine (in the brain of autistic child)
Autonomic Response (in the brain of autistic child)
Pro Inflammatory Cytokine, Chemokine & Activation of microglia (in the brain of autistic child)
High Inflammation (Collateral Damage - Traumatic CNS injury, Sensory motor dysfunction)
Medium Inflammation (Psychological Imbalance - Fear, Anxiety,Hyperactivity, Depression)
Low Inflammation (Reduced Neuronal Plasticity - Cognitive Impairment, Attention deficit)
Chronic High Inflammation Neuronal Damage - Neuro degenerative disease

Figure 2: Transient neuroinflammation from parental stress to children with ASD

Chronic or traumatic parental stress causes transient prenatal neuroinflammation, (Figure 2) i.e., increased proinflammatory cytokine, chemokine expression and activation of microglia which leads to: i) cognitive impairment, ii) psychological imbalance, iii) sensorimotor dysfunction and iv) neuronal damage.[11,12]

1.3. THERAPEUTIC EFFECT OF YOGA FOR AUTISM

Yogasana may be defined as a physical posture with breath awareness which facilitates the development of body awareness, concentration, memory and provides vital energy for children with ASD.[13] Yoga therapy improves sensory integration and motor imitations that enable persons with cognitive disabilities to make meaningful response by the integration of senses and functions of central nervous system.[14] Several evidences suggest that yoga increases gamma-aminobutyric acid (GABA) and parasympathetic activity which leads to improvement in cardiac autonomic function.[15,16]

1.4. PURPOSE OF THE STUDY

Several studies have showed that yoga is effective for children with autism spectrum disorder and can be improved with respect to behaviour. The study showed the feasibility of yoga therapy intervention for children with ASD by which reduction of the progression of neurodevelopmental disability is possible.[17] But the area for greater concern is the neurophysiological aspect of neuroinflammation, that is, neuromuscular and cardiovascular dysfunction in children with ASD. A common pathophysiology found in neuromuscular and cardiovascular dysfunctions is immune alteration and activation of microglia which is linked with altered behaviour in children with ASD.[11] Hence, the purpose of this study is to find the effectiveness of yoga therapy on neuroinflammation or the neuromuscular and cardiovascular functions, and is designed to improve neuroinflammation in children with ASD.

2. AIMS & OBJECTIVES

2.1. AIMS

2.1.1. To find the effect of yoga therapy on neuromuscular and cardiovascular functions in children with ASD.

2.1.2. To find the effect of yoga therapy on reduction of autism severity in children with ASD.

2.2. OBJECTIVES

2.2.1. To evaluate the effect of yoga therapy on anthropometric variables by measuring height, weight, body mass index (BMI).

2.2.2. To evaluate the effect of yoga therapy on neuromuscular function by measuring handgrip strength, visual reaction time.

2.2.3. To evaluate the effect of yoga therapy on cardiovascular function by measuring systolic blood pressure, diastolic blood pressure, heart rate.

2.2.4. To evaluate the effect of yoga therapy on reduction of autism severity using second edition high functioning Childhood Autism Rating Scale (CARS2-HF).

3. RESEARCH QUESTION

Is yoga therapy effective on neuromuscular and cardiovascular functions and in reduction of autism severity in children with ASD?

4. REVIEW OF LITERATURE

4.1. NEUROMUSCULAR VARIABLES

4.1.1. HANDGRIP STENGTH

Children with ASD have significantly poor handgrip strength and slow finger tapping speeds.[18,19] Handgrip strength examination may help in gross motor assessments to understand the nature of movement disorders.

Either fast or slow pranayama practice decreases sympathetic activity, resulting in mental relaxation and decreases autonomic arousal during isometric contraction.[20] Surya Namaskar practice significant decreased ($p<0.05$) diastolic blood pressure and increased ($p<0.001$) handgrip strength.[21] Yoga helps develop muscle strength by which motor execution performance and hand grip strength is improved.

4.1.2. VISUAL REACTION TIME

Visual reaction time helps to assess sensory-motor coordination which is a relevant factor for sensory-emotional synchronization, multisensory integration and motor skills.[13,22] Children with autism demonstrated slower reaction time and greater standard deviations compared with typically developing children.[23]

Yoga significantly decreased ($p<0.001$) both visual reaction time (VRT) and auditory reaction time (ART) which enhanced communication and social skills in children with ASD.[22] Yoga helps reduction of mean VRT and VRT variability which improves different cognitive mechanisms.

4.2. CARDIOVASCULAR VARIABLES

4.2.1. BLOOD PRESSURE & HEART RATE

Blood pressure and heart rate are non-invasive and quick assessment techniques for monitoring cardiovascular (CV) health which is essential in children with ASD.[13,24] Challenging behavior may be indicated by increased heart rate which was similar for children of different characteristics (age, autism severity, expressive language ability, overall developmental ability). It highlights the possibility of using physiological stress to predict challenging behavior in children with autism.[25–27] Several studies showed lowered cardiac vagal tone and imbalances of autonomous nervous system in children with ASD.[13] It was reviewed that there is no evidence on the effect of yoga therapy on blood pressure and heart rate in children with ASD.

Yoga enhances deep respiration which slows down the heart rate and blood pressure, stabilizing the system and reducing anxiety and balances chronic over stimulation of sympathetic nervous system.[28]

4.3. PSYCHOMETRIC VARIABLE

4.3.1. CHILDHOOD AUTISM RATING SCALE (CARS)

CAR Scale is used for the detection and diagnosis of autism. It consists of 14 categories for assessing behaviors associated with autism, and the 15th category rates the general impression of autism.[29]

Bhardwaj and Deorari (2014) found the effect of yoga intervention on children with ASD using CAR Scale.[30]

In summary, the review of literature found significance of neuromuscular and cardiovascular functions on muscle weakness, neuromuscular coordination, motor execution, lowered cardiac vagal tone and dysregulation of autonomic activity which causes poor social interaction, communication impairments, and overall autism severity in children with ASD.

Yoga therapy enhances deep respiration which slows down the heart rate and stabilizes blood pressure which reduces psychological balance.[28] Yoga increases parasympathetic nervous system (PNS) and gamma-aminobutyric acid (GABA) activity which leads to improvement in cardiac autonomic function.[13,16]

5. METHODOLOGY

5.1. Consolidated Standards of Reporting Trial (CONSORT)

The CONSORT diagram (Figure 3) illustrates flow of participants across the study, including screened, excluded, enrolled and randomized, pre-, mid- and post-data collection. It serves as a useful reference for interpreting the main findings of the trial.

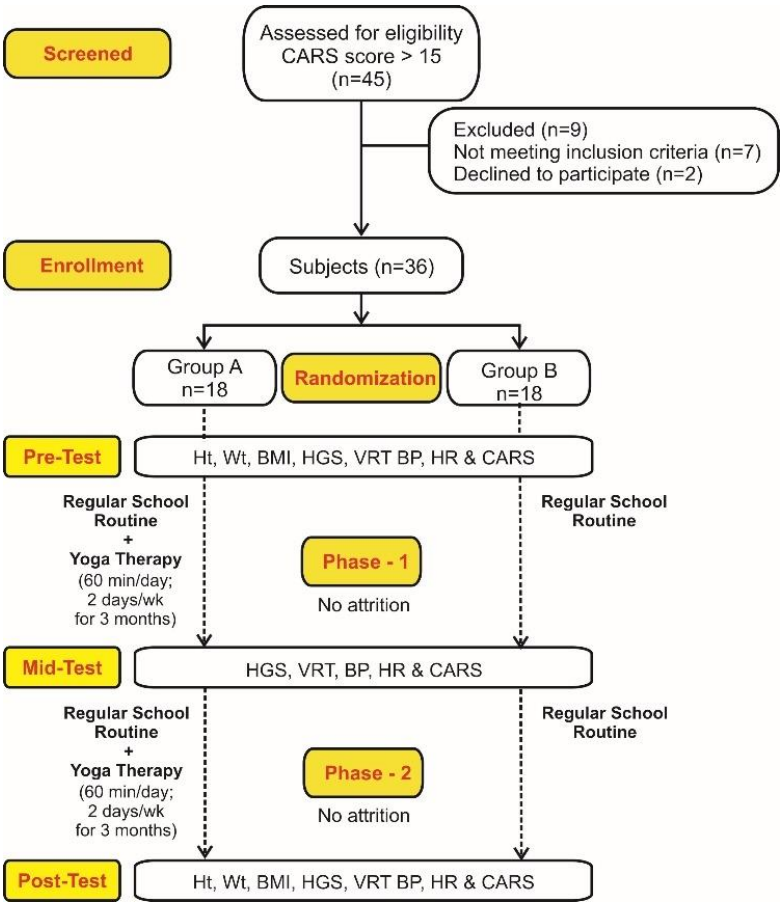

Figure 3: CONSORT flow diagram of study recruitment of children with ASD

5.2. Study Design

This study was a randomized controlled trial (RCT), randomly assigns participants into an experimental group or a control group. The study was approved by AVMC Institutional Human Ethical Committee [IEC No.: AV/IEC/2020/051] and registered with the Clinical Trials Registry of India [CTRI/2021/12/038561 - Trial Registered Prospectively].

5.3. Place of Study

The study was conducted in Satya Special School, Puducherry, India.

5.4. Recruitment

5.4.1. Study Population: Children with ASD

5.4.2. Inclusion Criteria

5.4.2.1. Diagnosis of autism (CARS>15): mild, moderate and severe.

5.4.2.2. Age: 6 – 25 years.

5.4.2.3. Able to perform yoga techniques with assistance.

5.4.2.4. Children with ASD and may have attention deficit hyperactivity disorder (ADHD) or gastrointestinal (GI) problems.

5.4.2.5. Informed consent obtained from parents and school authority.

5.4.3. Exclusion Criteria

5.4.3.1. Unable to perform yoga techniques with assistance.

5.4.3.2. Other co-morbidities (severe eczema, uncontrolled asthma and seizures).

5.4.4. Study Subjects

Eligible participants were recruited with mild, moderate and severe stages of ASD, aged between 6 and 25 years with regular school routine and have fulfilled inclusion and exclusion criteria.

5.4.5. Sample Size

Sample size was calculated using sample size calculator for two means and standard deviations (μ_1=83.50; μ_2=89.55; σ_1=6.0; σ_2=6.28) based on previous study involving children with ASD.[31]

Using the formula, $n = (Z_{\alpha/2}+Z_{\beta})^2 *2*\sigma^2 / d^2$

95 % confidence level (α is 0.05) = 1.96

80 % power (β is 0.2) = 0.84

Population variance (σ) = 6.14

Mean difference (d) = 6.05

n= 2*(1.96 + 0.8416)^ 2 *(6.14)^2 / (6.05) ^2 = **16.17**

A total sample size of 17 for each arm was required, resulting in a total of 34 for two arms. Considering that Satya Special School is a reputed school and maintains the percentage of dropout at 0-5%, a dropout of 5% was included. Therefore, minimum required sample size is 36.

5.4.6. Sampling Procedure: Purposive sampling method was used.

5.5. Randomization

Children with ASD (n=36) were equally randomized into two groups, yoga therapy group (YG) received yoga therapy along with regular school routine and control group (CG) received only regular school routine for a period of six months.

5.6. Study Tools

5.6.1. Anthropometric variables: Individual height was measured to the nearest millimeter by Easy Read Wall Mounted 200 cm Stadiometer (Fig 3) and weight was measured with OMRON Digital Body Weight Scale (Fig 4). Body mass index (BMI) was calculated by Quetelet index, that is, weight (in kilogram)/ height (in square meter). Both height and weight were measured before and after six months of the study period.

5.6.2. Neuromuscular variables

5.6.2.1. Handgrip strength was measured to the gram by CAMRY digital handgrip dynamometer. It is equipped with high precision strain gauge sensor; provides gripping power up to 198 lbs / 90 kgs, division: 0.2 lbs / 100 gm, unit: lb/kg; auto/manual shut off, low battery/overload indication; runs on

2 pieces of AAA batteries. Each handgrip test calibrates the amount of force currently applied and as soon as it is released it shows the maximum of isometric contraction of the 6 seconds.

5.6.2.2. Visual reaction time (VRT) was measured to the milliseconds by Reaction Time (RT) apparatus, Anand Agencies. RT apparatus calibrates visual and auditory stimuli with built in chronoscope; with four stimuli, two response keys and a ready signal; works on 230 volts A.C.

5.6.3. Cardiovascular variables: Blood pressure was measured to the millimeters of mercury by automatic Blood Pressure monitor – BP710. It is equipped with high precision ± 3 mmHg or 2% of reading; provides pressure of 0 to 299 mmHg, division: systolic BP/ diastolic BP, Unit: mmHg; automatic electric pump, pressure release valve and exhaust valve, low battery/overload indication; runs on 4 pieces of AAA batteries. Three different sized cuffs a) Large size soft cuff with arm circumference of 32-42 cm, b) Medium size soft cuff with arm circumference of 22-32 cm, and c) Small size soft cuff with arm circumference of 17-22 cm were employed based on the requirements.

5.6.4. Psychometric variable: Autism severity was measured to the score by high functioning Childhood Autism Rating Scale –second edition (CARS2-HF). The research scholar obtained permission from the corresponding author of CAR Scale second edition that help assess autism severity. CAR Scale is used for the detection and diagnosis of autism. It consists of 14 categories of behaviors associated with autism; the 15th category rates the general impression of autism. Each scale is rated with a score of 1 (normal), 2 (mildly abnormal), 3 (moderately abnormal), or 4 (severely abnormal). Midpoint scores of 1.5, 2.5, and 3.5 are also possible; higher scores are associated with a higher level of impairment. Total scores can range from a low of 15 to a high of 60; a score below 15 indicates that the individual is in the non-autistic range, score between 15 and 27.5 indicates mild autism, score between 28 and

33.5 indicates moderate autism, and score above 34 indicates severe autism.[29]

5.7. Yoga therapy protocol

Based on the pilot study[17] and copyrighted yoga practice for Divyangan by School of Yoga Therapy, Institute of Salutogenesis and Complementary Medicine [previous CYTER] the following practices were selected after expert validation (Table 1).

Table 1: Yoga therapy protocol

Sno.	Yoga practices*	Holding posture (counts)	Repetition (round)	Duration (min)
1	Play way jattis: (a) Right leg forward & backward	10	3	3
2	Play way jattis: (b) Left leg forward & backward	10	3	3
3	Tadasana	10	3	3
4	Vrkshasana	10	3	3
5	Padahastasana	10	3	3
6	Paschimottanasana	10	3	3
7	Pawanamuktasana	10	3	3
8	Jatharaparivrttasana	10	3	3
9	Bhujangasana	10	3	3
10	Sarvangasana	10	3	3
11	Adham Pranayama	10	3	3
12	Madhyam Pranayama	10	3	3
13	Adhyam Pranayama	10	3	3
14	Pranava Pranayama	10	3	3
15	Shavasana			3
	Total			45

* Subjected to individual's ability

5.8. Procedure

5.8.1. Children with ASD were screened by the clinical psychologist.

5.8.2. Those who were diagnosed and found eligible for the study were referred to yoga therapy intervention.

5.8.3. After fulfilling inclusion and exclusion criteria, subjects were randomized into yoga (n=18) and control (n=18) groups.

5.8.4. Pre-data, mid-data and post-data were collected by the same special educator under the supervision of clinical psychiatrist.

5.8.5. 60 minutes/session, and 2 sessions/week were given to subjects for a period of 6 months along with regular school routine in the yoga group and control group followed only regular school routine, and the attrition was zero in both groups.

5.8.6. Treatment outcome was evaluated by analysis of anthropometric, neuromuscular, cardiovascular and psychometric variables.

5.9. Statistical Analysis

5.9.1. Mean and standard deviation (SD) values are used to represent numerical parameters which are normally distributed.

5.9.2. Fisher's exact/Chi square test was used to compare categorical variables between groups.

5.9.3. Analysis of Variance (ANOVA) was used to compare variances across the means of different groups (pre, mid & post).

5.9.4. Post-hoc test was done to identify difference between the groups.

5.9.5. Delta percentage (Δ%) was calculated by the formula (post-pre/pre) X 100 for all outcome variables to evaluate pre-post change in the scores.

5.9.6. Treatment response was compared between the groups using Students' t-test with the Δ and Δ% values.

5.9.7. SPSS (version 16.0) was used for all statistical analyses.

6. RESULTS AND DISCUSSION

6.1. Baseline comparison of demographic and anthropometric variables and autism severity

The demographic and anthropometric variables of the subjects include age, gender, height and weight, and CARS score which were comparable at the baseline as determined by Students t test and Chi square test, as given in Table 2.

Table 2: Baseline comparison of anthropometric variables between groups using Chi-square and Student t tests

Variables	Yoga (n=18)	Control (n=18)	p value
Gender			
Male	16	14	0.367*
Female	2	4	
Age (yr)	13.28 ± 05.23	12.33 ± 04.65	0.571
Height (cm)	149.50 ± 23.93	145.28 ± 19.03	0.562
Weight (kg)	43.03 ± 20.33	43.59 ± 16.64	0.929
BMI	18.10 ± 04.84	19.93 ± 04.43	0.244
Autism severity	50.33 ± 04.75	50.86 ± 04.82	0.743

* Fisher's exact test

6.2. Objective 1: Effect of yoga therapy on anthropometric variables

Yoga therapy showed a non-significant change on height, weight, and BMI in children with ASD, as given in Table 3.

Table 3: Comparison of demographic variables between groups using Student t tests

Vari-ables	Pre			Post		
	YG	CG	p value	YG	CG	p value
Height	149.50 ± 23.93	145.28 ± 19.03	0.562	149.94 ± 24.02	145.94 ± 19.24	0.585
Weight	43.03 ± 20.33	43.59 ± 16.64	0.929	43.78 ± 20.88	44.39 ± 16.84	0.924
BMI	18.10 ± 04.84	19.93 ± 04.43	0.244	18.29 ± 04.99	20.13 ± 04.53	0.254

* $p<0.05$ significant between groups using Students t test

6.3. Objective 2: Effect of yoga therapy on neuromuscular function

Phase 1, 2 & 3 are defined as time interval between pre-mid, mid-post and pre-post respectively.

Phase 1: HGS showed significantly increased (8.94 ± 7.20, **Δ=4.42, p<0.027**) in YG whereas slightly increased (4.32 ± 2.42, **Δ**=0.35) in CG. VRT showed mild positive change (1279.76 ± 543.76, **Δ**= -59.85) in YG whereas mild negative change (1533.56 ± 706.21, **Δ**=3.72) in CG. **Phase 2:** HGS showed slightly increased in both YG (9.26 ± 4.67, **Δ**= 0.32) and CG (4.60 ± 2.93, **Δ**= 0.28). VRT showed significantly decreased (797.50 ± 323.16, **Δ= -482.26, p<0.002)** in YG, whereas slightly increased (1925.06 ± 713.48, **Δ**=391.50) in CG. **Phase 3:** HGS significantly increased

(Δ=4.74, p<0.001) in YG and slightly increased (**Δ=**0.62) in CG. VRT showed significantly decreased (**Δ= -542.11, p< 0.005**) in YG and non-significantly increased (Δ=395.22) in CG.

Table 4: Comparison of mean values of HGS and VRT between groups using repeated measures of analysis of variance (RM-ANOVA)

Variables	Times	Yoga (n=18)	Control (n=18)	p value
HGS	Pre	4.52 ± 2.10	3.98 ± 2.19	0.453
	Mid	**8.94 ± 7.20***	4.32 ± 2.42	**0.014**
	Post	**9.26 ± 4.67**$^{***\#\#\$\$}$	4.60 ± 2.93	**0.001**
	p value	**0.004**	0.256	
VRT	Pre	1339.61 ± 760.34	1529.83 ± 765.21	0.460
	Mid	1279.76 ± 543.76	1533.56 ± 706.21	0.235
	Post	**797.50 ± 323.16**$^{***\#\#\#\$\$}$	1925.06 ± 713.48	**0.000**
	p value	**0.001**	0.104	

* p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test; # p<0.05, ## p<0.01, ### p<0.001 significant within groups using RM-ANOVA; $ p<0.05, $$ p<0.01, $$$ p<0.001 significant between groups using RM-ANOVA.

Table 5: Result of post hoc comparisons of HGS and VRT within and between groups

Vari-ables	**(I - J) Time**	**Within**				**Between**	
		YG		CG		Mean difference (YG-CG)	p value
		Mean difference	p value	Mean difference	p value		
HGS	Mid – Pre	**4.42**$^{\#}$	**0.027**	0.35	1.000	**3.27**$^{\$\$}$	**0.005**
	Post – Mid	0.32	1.000	0.28	1.000		
	Post – Pre	**4.74**$^{\#\#\#}$	**0.000**	0.62	0.284		
VRT	Mid – Pre	-59.85	1.000	3.72	1.000	**-523.86**$^{\$\$}$	**0.003**
	Post – Mid	**-482.26**$^{\#\#}$	**0.002**	391.50	0.176		
	Post – Pre	**-542.11**$^{\#\#}$	**0.005**	395.22	0.097		

#p<0.05, ##p<0.01, ###p<0.001 by within group; $p<0.05, $$p<0.01, $$$p<0.001 by between groups using RM-ANOVA

This study showed that yoga therapy significantly increased HGS (**Δ=3.27, p<0.005**) and significantly decreased VRT (**Δ= -523.86, p<0.003**), as given in Table 4 & 5.

6.4. Objective 3: Effect of yoga therapy on cardiovascular function

Phase 1: SBP showed slightly increased in both YG (106.22 ± 15.56, Δ=5.39) and CG (111.67 ± 14.12, Δ=8.17). DBP showed **significantly increased in both** YG (69.17 ± 14.30, **Δ=10.00, p<0.013**) and CG (74.50 ± 13.26, **Δ=14.06, p<0.020**). HR showed significantly increased (94.17 ±

10.66, **Δ=7.44, p<0.029**) in YG and slightly increased (95.94 ± 18.13, Δ= 5.33) in CG. **Phase 2:** SBP showed significantly increased (117.39 ± 11.28**, Δ=11.17, p<0.001**) in YG and slightly increased (112.89 ± 12.53**, Δ=**1.22) in CG. DBP showed significantly increased (75.56 ± 12.82, **Δ=6.39, p<0.005**) in YG and slightly increased (77.67 ± 11.97, Δ=3.17) in CG. HR showed slightly decreased in both YG (88.11 ± 9.61, Δ= -6.06) and CG (93.00 ± 6.10, Δ= -2.94). **Phase 3:** SBP showed **significantly increased in both** YG (**Δ=16.56, p<0.001**) and CG (**Δ=9.40, p<0.040**). DBP showed **significantly increased in both** YG (**Δ=16.39, p<0.001**) and CG (**Δ=17.22, p<0.001**). HR showed slightly increased in both YG (Δ=1.39) and CG (Δ=2.39).

Table 6: Comparison of mean values of SBP, DBP and HR between groups

Variables	Times	Yoga (n=18)	Control (n=18)	p value
SBP	Pre	100.83 ± 12.43	103.50 ± 15.61	0.574
	Mid	106.22 ± 15.56	111.67 ± 14.12	0.279
	Post	**117.39 ± 11.28**$^{\#\#\#}$	**112.89 ± 12.53**$^{\#\#}$	0.265
	p value	**0.001**	**0.009**	
DBP	Pre	59.17 ± 11.63	60.44 ± 18.60	0.806
	Mid	69.17 ± 14.30	74.50 ± 13.26	0.254
	Post	**75.56 ± 12.82**$^{\#\#\#}$	**77.67 ± 11.97**$^{\#\#\#}$	0.613
	p value	**0.000**	**0.000**	
HR	Pre	86.72 ± 8.93	90.61 ± 10.76	0.246
	Mid	94.17 ± 10.66	95.94 ± 18.13	0.722
	Post	**88.11 ± 9.61**$^{\#}$	93.00 ± 6.10	0.077
	p value	**0.010**	0.288	

* p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test; # p<0.05, ## p<0.01, ### p<0.001 significant within groups using RM-ANOVA; $ p<0.05, $$ p<0.01, $$$ p<0.001 significant between groups using RM-ANOVA.

Table 7: Result of post hoc comparisons of SBP, DBP and HR within and between groups

Vari-ables	(I - J) Time	Within				Between	
		YG		CG		Mean difference (YG-CG)	p value
		Mean difference	p value	Mean difference	p value		
SBP	Mid – Pre	5.39	0.339	8.17	0.068	-1.20	0.755
	Post – Mid	**11.17**$^{\#\#\#}$	**0.001**	1.22	1.000		
	Post – Pre	**16.56**$^{\#\#\#}$	**0.001**	**9.40**$^{\#}$	**0.040**		
DBP	Mid – Pre	**10.00**$^{\#}$	**0.013**	**14.06**$^{\#}$	**0.020**	-2.91	0.444
	Post – Mid	**6.39**$^{\#\#}$	**0.005**	3.17	1.000		

	Post – Pre	**16.39$^{\#\#\#}$**	**0.001**	**17.22$^{\#\#\#}$**	**0.001**		
HR	Mid – Pre	**7.44$^{\#}$**	**0.029**	5.33	0.616	-3.52	0.234
	Post – Mid	-6.06	0.116	-2.94	1.000		
	Post – Pre	1.39	1.000	2.39	0.527		

#p<0.05, ##p<0.01, ###p<0.001 by within group; $p<0.05, $$p<0.01, $$$p<0.001 by between groups using RM-ANOVA

This study showed that there is ***no significant difference*** in SBP (Δ= -1.20, p>0.05), DBP (Δ= -2.91, p>0. 05) and HR (Δ= -3.52, p>0.05) between groups, as given in Table 6 & 7.

6.5. Objective 4: Effect of yoga therapy on reduction of autism severity

Phase 1: CARS score showed significantly decreased (45.08 ± 5.69, **Δ= -5.25, p<0.001**) in YG whereas mild positive change (50.69 ± 4.52, Δ= -0.17) in CG. **Phase 2:** CARS score showed significantly decreased (39.69 ± 6.62, **Δ= -5.39, p<0.001**) in YG whereas mild positive change (50.33 ± 4.79, Δ= -0.36) in CG. **Phase 3:** CARS score showed significantly decreased (**Δ= -10.64, p<0.001**) in YG whereas mild positive change (Δ= -0.53) in CG.

Table 8: Comparison of mean values of CARS score between groups

Vari-ables	**Times**	**Yoga (n=18)**	**Control (n=18)**	**p value**
CARS	Pre	50.33 ± 4.75	50.86 ± 4.82	0.743
	Mid	**45.08 ± 5.69****	50.69 ± 4.52	**0.002**
	Post	**39.69 ± 6.62$^{***\#\#\#}$**	50.33 ± 4.79	**0.000**
	p value	**0.000**	0.594	

* p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test; # p<0.05, ## p<0.01, ### p<0.001 significant within groups using RM-ANOVA; $ p<0.05, $$ p<0.01, $$$ p<0.001 significant between groups using RM-ANOVA.

Table 9: Result of post hoc comparisons of CARS score within & between groups

Vari-ables	**(I - J) Time**	**Within**				**Between**	
		YG		CG		Mean difference (YG-CG)	p value
		Mean difference	p value	Mean difference	p value		
CARS	Mid – Pre	**-5.25$^{\#\#\#}$**	**0.001**	-0.17	1.000	**-6.74$^{\$\$}$**	**0.002**
	Post – Mid	**-5.39$^{\#\#\#}$**	**0.001**	-0.36	1.000		
	Post – Pre	**-10.64$^{\#\#\#}$**	**0.001**	-0.53	0.637		

#p<0.05, ##p<0.01, ###p<0.001 by within group; $p<0.05, $$p<0.01, $$$p<0.001 by between groups using RM-ANOVA

This study showed that yoga therapy ***significantly decreased*** CARS score (**Δ=-6.74, p<0.002**), as given in Table 8, 9, 10 & 11.

Table 10: Comparison of mean values of categories of CARS scores between groups

Categories	Times	Yoga (n=18)	Control (n=18)	p value
Social-Emotional understanding (C1)	Pre	3.33 ± 0.34	3.44 ± 0.48	0.431
	Mid	**3.03 ± 0.40****	3.47 ± 0.47	**0.004**
	Post	**2.61 ± 0.63****###$$	3.42 ± 0.52	**0.000**
	p value	**0.000**	0.697	
Emotional expression & regulation of emotions (C2)	Pre	3.39 ± 0.37	3.36 ± 0.68	0.880
	Mid	**3.06 ± 0.45***	3.44 ± 0.48	**0.017**
	Post	**2.53 ± 0.76****###$	3.36 ± 0.70	**0.002**
	p value	**0.000**	0.584	
Relating to people (C3)	Pre	3.36 ± 0.45	3.36 ± 0.41	1.000
	Mid	3.08 ± 0.58	3.42 ± 0.52	0.077
	Post	**2.72 ± 0.60****###$	3.44 ± 0.38	**0.000**
	p value	**0.000**	0.671	
Body use (C4)	Pre	3.28 ± 0.46	3.36 ± 0.41	0.572
	Mid	**2.78 ± 0.60****	3.28 ± 0.39	**0.006**
	Post	**2.69±0.62****###$$	3.39 ± 0.47	**0.001**
	p value	**0.000**	0.385	
Object use in play (C5)	Pre	3.50 ± 0.38	3.47 ± 0.47	0.847
	Mid	**3.06 ± 0.51****	3.53 ± 0.53	**0.010**
	Post	**2.81 ± 0.60****###$	3.47 ± 0.47	**0.001**
	p value	**0.000**	0.661	
Adaptation to change/ Restricted interests (C6)	Pre	3.58 ± 0.35	3.53 ± 0.50	0.702
	Mid	**3.17 ± 0.42***	3.56 ± 0.51	**0.018**
	Post	**2.83 ± 0.62****###$	3.56 ± 0.42	**0.000**
	p value	**0.000**	0.952	
Visual response (C7)	Pre	2.97 ± 0.58	2.81 ± 0.62	0.412
	Mid	**2.53 ± 0.67***	2.92 ± 0.39	**0.042**
	Post	**2.08 ± 0.75***###	2.64 ± 0.84	**0.044**
	p value	**0.000**	0.240	
Listening response (C8)	Pre	2.97 ± 0.65	2.94 ± 0.66	0.900
	Mid	2.56 ± 0.75	3.00 ± 0.57	0.052
	Post	**2.19 ± 0.82###**	2.64 ± 0.84	0.118
	p value	**0.000**	0.052	
Taste, Smell and Touch response and use (C9)	Pre	3.31 ± 0.55	3.17 ± 0.57	0.460
	Mid	2.94 ± 0.59	3.17 ± 0.49	0.226
	Post	**2.19 ± 0.89###**	**2.69 ± 0.97#**	0.117
	p value	**0.000**	**0.021**	
Fear or Anxiety (C10)	Pre	3.56 ± 0.38	3.58 ± 0.43	0.838
	Mid	3.33 ± 0.42	3.56 ± 0.45	0.135
	Post	**2.86 ± 0.48****###$	3.50 ± 0.51	**0.000**
	p value	**0.000**	0.758	

Verbal communication (C11)	Pre	3.14 ± 0.48	3.33 ± 0.64	0.310
	Mid	2.75 ± 0.65	3.11 ± 0.56	0.082
	Post	**2.72 ± 0.62**$^{***###\$}$	3.56 ± 0.59	**0.000**
	p value	**0.001**	**0.003**	
Non-verbal communication (C12)	Pre	3.44 ± 0.45	3.61 ± 0.44	0.269
	Mid	**3.22 ± 0.52***	3.61 ± 0.47	**0.025**
	Post	**2.89 ± 0.63**$^{***###\$\$}$	3.75 ± 0.39	**0.000**
	p value	**0.000**	0.115	
Thinking/ Cognitive integration skills (C13)	Pre	3.50 ± 0.38	3.67 ± 0.38	0.201
	Mid	**3.25 ± 0.46***	3.61 ± 0.44	**0.022**
	Post	**2.86 ± 0.41**$^{***###\$\$\$}$	3.64 ± 0.38	**0.000**
	p value	**0.000**	0.728	
Level and Consistency of Intellectual response (C14)	Pre	3.50 ± 0.38	3.67 ± 0.38	0.201
	Mid	**3.28 ± 0.46***	3.58 ± 0.43	**0.047**
	Post	**2.83 ± 0.42**$^{***###\$\$\$}$	3.67 ± 0.38	**0.000**
	p value	**0.000**	0.280	
General impressions (C15)	Pre	3.50 ± 0.34	3.56 ± 0.45	0.680
	Mid	**3.06 ± 0.45***	3.44 ± 0.45	**0.014**
	Post	**2.86 ± 0.61**$^{***###\$\$}$	3.61 ± 0.32	**0.000**
	p value	**0.001**	0.145	

*p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test; #p<0.05, ## p<0.01, ### p<0.001 significant within groups using RM-ANOVA; $p<0.05, $$ p<0.01, $$$ p<0.001 significant between groups using RM-ANOVA.

Table 11: Result of post hoc comparisons of categories of CARS scores within and between groups.

Categories	Times	Within				Between	
		YG		CG		Mean difference (YG-CG)	p value
		Mean difference	p value	Mean difference	p value		
C1	Mid – Pre	**-0.31**$^{###}$	**0.000**	0.03	1.000	**-0.46**$^{\$\$}$	**0.004**
	Post – Mid	**-0.42**$^{##}$	**0.002**	-0.06	1.000		
	Post – Pre	**-0.72**$^{###}$	**0.000**	-0.03	1.000		
C2	Mid – Pre	**-0.33**$^{###}$	**0.000**	0.08	0.994	**-0.57**$^{#}$	**0.030**
	Post – Mid	**-0.53**$^{##}$	**0.004**	-0.08	1.000		
	Post – Pre	**-0.86**$^{###}$	**0.000**	0.00	1.000		
C3	Mid – Pre	**-0.28**$^{###}$	**0.001**	0.06	1.000	**-0.48**$^{\$}$	**0.018**
	Post – Mid	**-0.36**$^{#}$	**0.044**	0.03	1.000		
	Post – Pre	**-0.64**$^{###}$	**0.000**	0.08	1.000		
C4	Mid – Pre	**-0.50**$^{###}$	**0.000**	-0.08	0.562	**-0.41**$^{\$\$}$	**0.006**
	Post – Mid	-0.08	1.000	0.11	0.894		
	Post – Pre	**-0.58**$^{###}$	**0.000**	0.03	1.000		
C5	Mid – Pre	**-0.44**$^{###}$	**0.000**	0.06	0.994	**-0.46**$^{\$}$	**0.013**
	Post – Mid	-0.25	0.395	-0.06	1.000		
	Post – Pre	**-0.69**$^{###}$	**0.000**	0.00	1.000		
C6	Mid – Pre	**-0.42**$^{###}$	**0.000**	0.03	1.000	**-0.52**$^{\$}$	**0.011**
	Post – Mid	-0.33	0.088	0.00	1.000		
	Post – Pre	**-0.75**$^{###}$	**0.000**	0.03	1.000		
C7	Mid – Pre	**-0.44**$^{###}$	**0.000**	0.11	1.000	-0.48	0.163
	Post – Mid	**-0.44**$^{#}$	**0.040**	-0.28	0.567		
	Post – Pre	**-0.89**$^{###}$	**0.000**	-0.17	0.629		

C8	Mid – Pre	**-0.42$^{\#\#\#}$**	**0.000**	0.06	1.000	-0.32	0.199
	Post – Mid	**-0.36$^{\#}$**	**0.033**	-0.36	0.200		
	Post – Pre	**-0.78$^{\#\#\#}$**	**0.000**	-0.31	0.051		
C9	Mid – Pre	**-0.36$^{\#\#\#}$**	**0.000**	0.00	1.000	-0.43	0.330
	Post – Mid	**-0.75$^{\#\#\#}$**	**0.001**	-0.47	0.109		
	Post – Pre	**-1.11$^{\#\#\#}$**	**0.000**	**-0.47$^{\#}$**	**0.037**		
C10	Mid – Pre	**-0.22$^{\#\#}$**	**0.005**	-0.03	1.000	**-0.40$^{\$}$**	**0.022**
	Post – Mid	**-0.47$^{\#\#\#}$**	**0.001**	-0.06	1.000		
	Post – Pre	**-0.69$^{\#\#\#}$**	**0.000**	-0.08	1.000		
C11	Mid – Pre	**-0.39$^{\#\#}$**	**0.002**	-0.22	0.170	**-0.43$^{\$}$**	**0.012**
	Post – Mid	-0.03	1.000	**0.44$^{\#}$**	**0.012**		
	Post – Pre	**-0.42$^{\#\#}$**	**0.007**	0.22	0.170		
C12	Mid – Pre	**-0.22$^{\#}$**	**0.021**	0.00	1.000	**-0.46$^{\$\$}$**	**0.003**
	Post – Mid	**-0.33$^{\#}$**	**0.041**	0.14	0.406		
	Post – Pre	**-0.56$^{\#\#\#}$**	**0.001**	0.14	0.168		
C13	Mid – Pre	**-0.25$^{\#\#\#}$**	**0.002**	-0.06	1.000	**-0.41$^{\$\$\$}$**	**0.001**
	Post – Mid	**-0.39$^{\#\#}$**	**0.005**	0.03	1.000		
	Post – Pre	**-0.64$^{\#\#\#}$**	**0.000**	-0.03	1.000		
C14	Mid – Pre	**-0.22$^{\#\#}$**	**0.005**	-0.08	0.562	**-0.44$^{\$\$\$}$**	**0.001**
	Post – Mid	**-0.44$^{\#\#}$**	**0.002**	0.08	0.806		
	Post – Pre	**-0.67$^{\#\#\#}$**	**0.000**	0.00	1.000		
C15	Mid – Pre	**-0.44$^{\#\#\#}$**	**0.000**	-0.11	0.489	**-0.46$^{\$\$}$**	**0.003**
	Post – Mid	-0.19	0.654	0.17	0.332		
	Post – Pre	**-0.64$^{\#\#\#}$**	**0.001**	0.06	1.000		

#p<0.05, ##p<0.01, ###p<0.001 by within group; $p<0.05, $$p<0.01, $$$p<0.001 by between groups using RM-ANOVA

Table 12: Comparison of delta & delta % of categories of CARS within and between groups

Behavioral functions	Within				Between	
	Delta		Delta%		Delta	Delta%
	YG	CG	YG	CG		
Social-emotional understanding	-0.72$^{\#\#\#}$	-0.02	-21.62	-0.58	0.46	13.69$^{***\$\$}$
Emotional expression and regulations of emotions	-0.86$^{\#\#\#}$	0.00	-25.41	0.00	0.57	16.99$^{**\$}$
Relating to people	-0.64$^{\#\#\#}$	0.08	-19.01	2.48	0.48	14.38$^{***\$}$
Body use	-0.58$^{\#\#\#}$	0.03	-17.80	0.83	0.41	12.25$^{***\$\$}$
Object use in play	-0.69$^{\#\#\#}$	0.00	-19.84	0.00	0.46	13.20$^{***\$}$
Adaptation in change/ Restricted interests	-0.75$^{\#\#\#}$	0.03	-20.93	0.79	0.52	14.63$^{***\$}$
Visual response	-0.89$^{\#\#\#}$	-0.17	-29.91	-5.94	0.48	16.50*
Listening response	-0.78$^{\#\#\#}$	-0.31	-26.17	-10.38	0.32	10.70
Taste, smell, and touch response and use	-1.11$^{\#\#\#}$	-0.47$^{\#}$	-33.61	-14.91	0.43	13.18
Fear or Anxiety	-0.69$^{\#\#\#}$	-0.08	-19.53	-2.33	0.40	11.30$^{***\$}$
Verbal communication	-0.42$^{\#\#\#}$	0.22$^{\#\#}$	-13.27	6.67	0.43	13.18$^{***\$}$
Non-verbal communication	-0.56$^{\#\#\#}$	0.14	-16.13	3.85	0.46	13.13$^{***\$\$}$
Thinking/Cognitive Integration skills	-0.64$^{\#\#\#}$	-0.03	-18.25	-0.76	0.41	11.35$^{***\$\$\$}$
Level and consistency of intellectual response	-0.67$^{\#\#\#}$	0.00	-19.05	0.00	0.44	12.37$^{***\$\$\$}$
General expressions	-0.64$^{\#\#\#}$	0.06	-18.25	1.56	0.46	13.13$^{***\$\$}$
Total CARS	-10.64$^{\#\#\#}$	-0.53	-21.14	-1.04	6.74	13.32$^{***\$\$}$

*p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test; $^{\#}$p<0.05, $^{\#\#}$ p<0.01, $^{\#\#\#}$ p<0.001 significant within groups using RM-ANOVA; $^{\$}$p<0.05, $^{\$\$}$ p<0.01, $^{\$\$\$}$ p<0.001 significant between groups using RM-ANOVA.

6.6. Impact of yoga therapy

6.6.1. On neuromuscular function

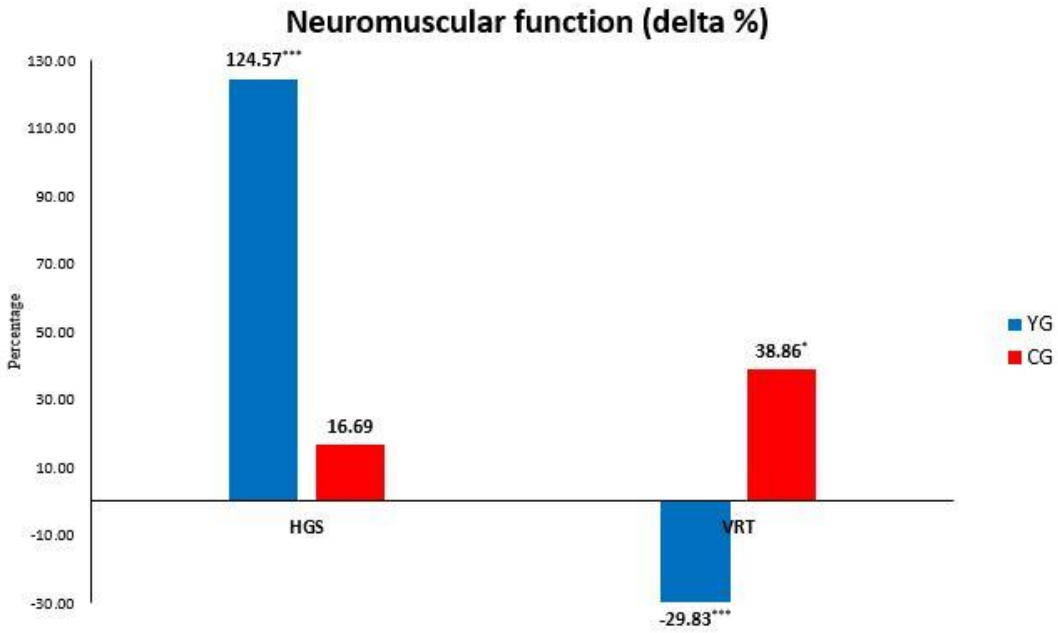

Chart 1: Comparison of delta% of HGS and VRT between groups

6.6.2. On cardiovascular function

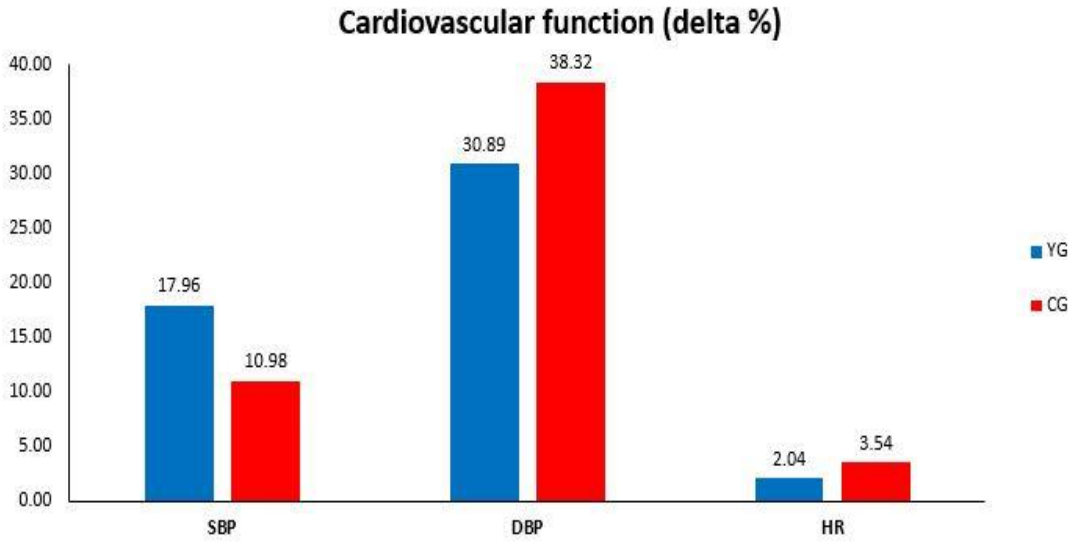

Chart 2: Comparison of delta% of HGS and VRT between groups

6.6.3. On autism severity

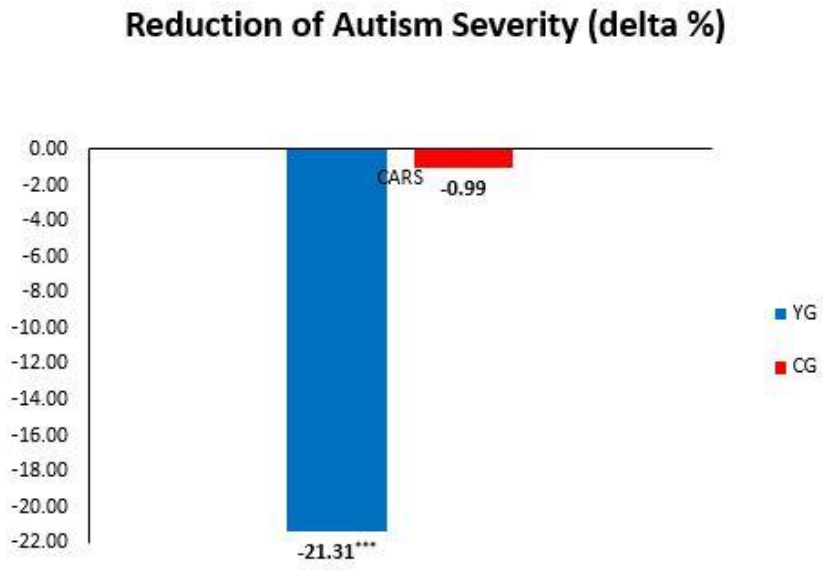

Chart 3a: Comparison of delta% of CARS score between groups

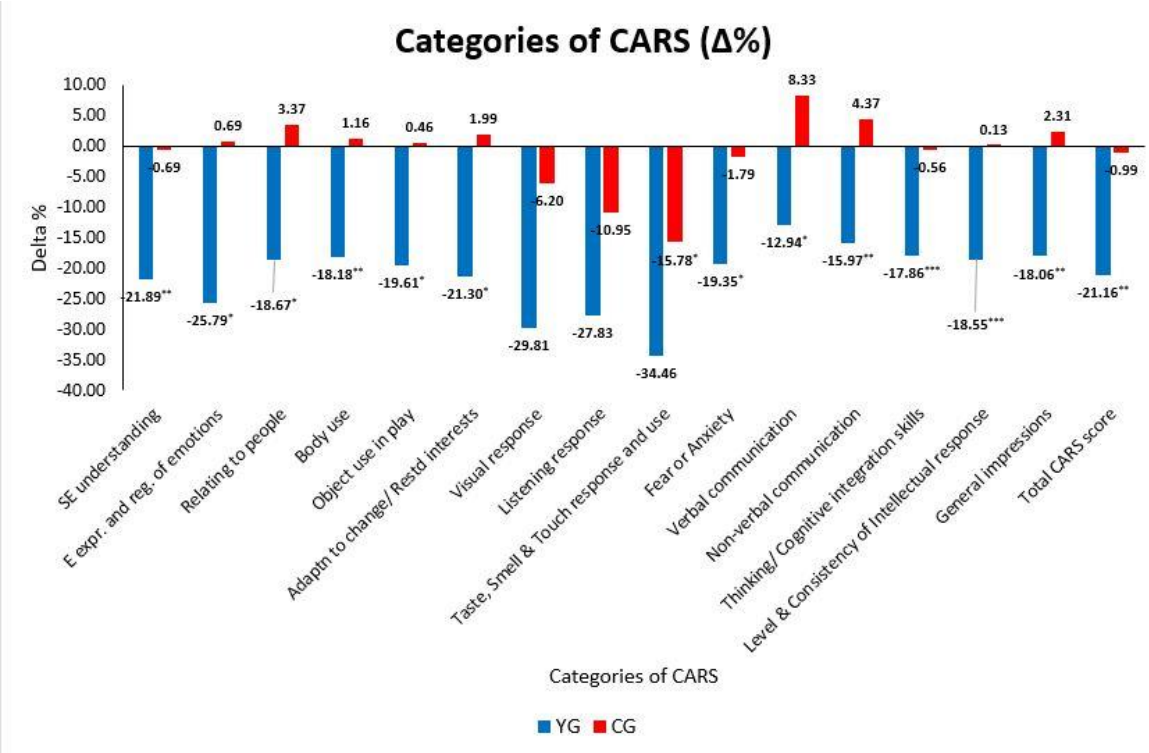

Chart 3b: Comparison of delta% of the categories of CARS scores between groups

6.6.4. Correlation of the effect of neuromuscular and cardiovascular functions with autism severity.

Table 13: Correlation of delta CARS with delta-values of BMI, HGS, VRT, SBP, DBP and HR

Delta values	BMI	HGS	VRT	SBP	DBP	HR
CARS (n=36)	0.016	-0.540***	0.535***	-0.218	0.108	0.106
Sig. (2-tailed)	0.928	0.001	0.001	0.201	0.530	0.538

Pearson correlation is significant at *p<0.05, **p<0.01, ***p<0.001 (2-tailed).

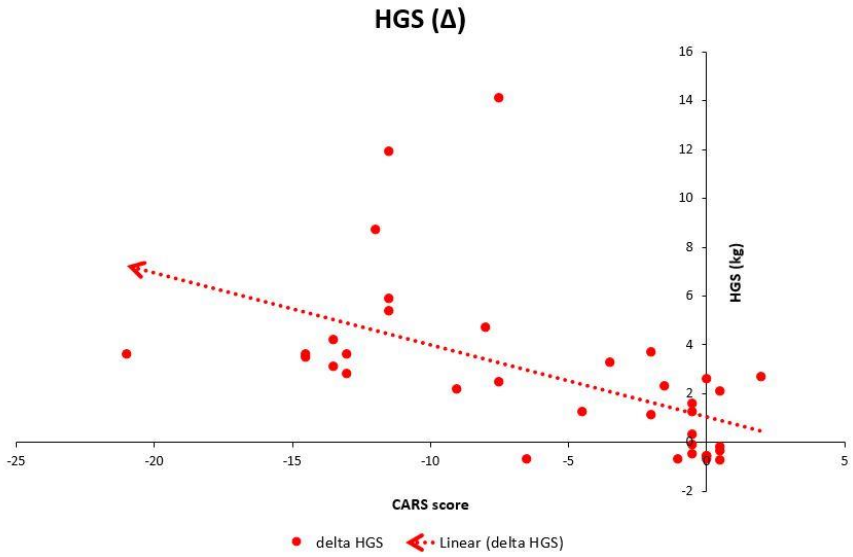

Chart 4: Correlation of delta value of HGS with CARS score

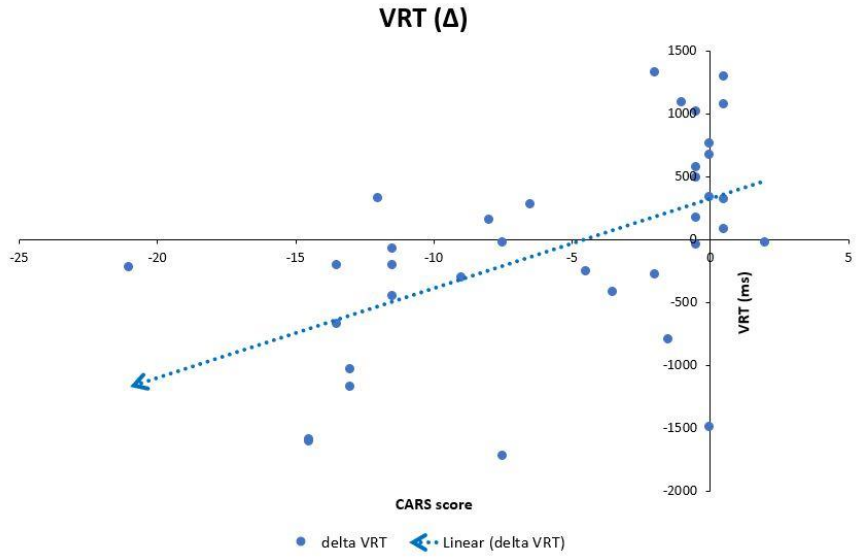

Chart 5: Correlation of delta value of VRT with CARS score

6.6.5. Comparison of obtained alternative hypothesis

HGS, VRT and CARS reject null hypothesis (H_0) i.e., accept alternative hypothesis. Therefore, yoga therapy improves neuromuscular function and reduction of autism severity in children with ASD. SBP, DBP and HR accept null hypothesis i.e., reject alternative hypothesis. Hence yoga therapy may improve cardiovascular function in children with ASD, as given in Table 14.

Table 14: Comparison of delta% of primary variables between groups

Variables	Delta%		p value	Alternative Hypothesis
	YG	CG		
HGS	124.57 ± 95.00***	16.69 ± 48.33	**0.000**	Accept
VRT	-29.83 ± 31.50***	38.86 ± 50.06	**0.000**	Accept
SBP	17.96 ± 17.53	10.98 ± 18.61	0.255	Reject
DBP	30.89 ± 27.59	38.32 ± 40.87	0.527	Reject
HR	02.04 ± 09.81	3.54 ± 9.20	0.640	Reject
CARS	-21.31 ± 09.96***	-0.99 ± 3.13	**0.000**	Accept

*p<0.05, ** p<0.01, *** p<0.001 significant between groups using Students t-test

7. SUMMARY & CONCLUSION

This study showed that yoga therapy significantly increased MD of HGS (+3270 g) and significantly decreased MD of VRT (-523.86 ms), Chart 1, 4 & 5 which can be attributed to improvement in neuromuscular admittance through the speed of sensorimotor cycle, detection of the initial stimulus, transfer of the information through the afferent nerves, generation of the response from the central nervous system and the final response in children with ASD.[22,32]

The study showed that yoga therapy slightly decreased MD of SBP (-1.20), DBP (-2.91) and HR (-3.52), Chart 2 which can be attributed to improvement in cardiac autonomic balance in children with ASD.[33]

The study showed that yoga therapy ***significantly decreased*** MD ($p<0.01$) in total CARS score (-6.74), Chart 3a. The following categories of CARS (Chart 3b) i.e., impaired behaviors of autism were reduced in children with ASD, as given in Table 12. Thus, this study drawn a postulated mechanism as to how yoga therapy improves neuromuscular function, cardiac autonomic balance and reduces autism severity in children with ASD which supported by valid references.

A six-month period of bi-weekly yoga therapy showed significant improvement in HGS, VRT and CARS2-HF with non-significant positive changes in BP and HR in children with ASD. It may be attributed to better balance and integration of neuromuscular function and improved cardiac autonomic balance after yoga therapy in children with ASD. Overall improvement of CARS score can be attributed to harmonization of mind-body-emotion through yoga therapy that also helps develop social skills and promotes self-confidence. Parents and teachers reported that autism severity was reduced. Thus, these results highlight the need to develop a daily practice of yoga in children with ASD.

8. LIMITATIONS & SUGGESTIONS

8.1. Limitations of the study

8.1.1. In Children with ASD, mixed categories of subject with respect to

8.1.1.1. Chronological age (6 to 25 years)

8.1.1.2. Special education (Educable, Trainable, and Custodial groups)

8.1.1.3. Autism intensity level (Mild, Moderate and Severe stages)

8.1.2. There is a preponderance of males between 13 – 25 years, due to COVID19 restrictions and general school dropout among females following puberty in children with ASD.

8.1.3. The performance of yoga practice was limited with assistance (1:9) in children with ASD.

8.1.4. Each practice was performed only 3 times and 10 counts (30 seconds) per time.

8.2. Suggestions for the future study

8.2.1. This study offers future directions for yoga research in children with ASD, similar studies can be conducted with

8.2.1.1. larger sample size.

8.2.1.2. pupil teacher ratio of 1:1 for severe, 3:1 for moderate, or 6:1 for mild autism.

8.2.1.3. longer duration (holding time and repetition) of each technique.

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10. APPENDICES

10.1. **Review article**: Yoga as a therapeutic tool in autism: A detailed review, Yoga Mimamsa (indexed **UGC-CARE**)

REVIEW ARTICLE

Yoga as a therapeutic tool in autism: A detailed review

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ABSTRACT

Autism is a complex neurodevelopmental disorder affecting systems of the body and behavior. Its growth rate is approximately 3% in children. This review was undertaken to search and critically analyze the literature about musculoskeletal, cardiovascular and neurological function, and behavioral outcomes of yoga interventions for individuals with autism spectrum disorder. This systematic review has four-stage screening process and rigorous critical appraisal, which resulted in the inclusion of 36 studies. As a result, in children with autism spectrum disorder with (i) the presence of muscle weakness: yoga may decrease sympathetic activity and autonomic arousal and thereby improve handgrip strength (HGS); (ii) lowered cardiac vagal tone and elevated sympathetic tone, resulting in autonomic abnormalities including impaired language, attention, and cognition: yoga reduces blood pressure and improves attention without sympathetic activation; (iii) slower reaction times and greater standard deviations: Pranayama practice enhances central processing ability; and (iv) sensory processing issues with behavior regulations give rise to the presence of repetitive behaviors: yoga improves sensory integration, motor imitations, communications, and their own thoughts and behaviors related to physical, social, and emotional well-being. Hence, this review of clinical studies suggests that approach built on yoga intervention is worth pursuing. Desired outcomes include reduction of autism rate and improved quality of life.

Key Words: Cognitive function, musculoskeletal function, neurological development, quality of life, yoga therapy

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INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder affecting an average of one in 37 children, and these conditions led to increase in the estimates from 13.6% to 16.8% (Suresh, 2018; Arora et al., 2018; Baio et al., 2018). The awareness and diagnosis of ASD, along with the limitations of current therapies, has necessitated more research for better treatments to improve lifelong outcomes and the dissemination of educational programs to the autism community. In the past decade, many researchers have investigated the effects of yoga on markers of impairment of social interaction/communication, stereotyped behavior, and sensory dysfunction.

Aim

To review the efficacy of yoga on the following functions and behaviors among individuals with ASD:

i. Musculoskeletal function
ii. Cardiovascular function
iii. Neurological function
iv. Behaviors.

Objectives

To review the role of yoga through the following parameters among children with ASD:.

i. Musculoskeletal function : Handgrip strength

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10.2. **Pilot study**: Effect of Yoga Therapy on Neuromuscular Function and Reduction of Autism Severity in Children with Autism Spectrum Disorder: A Pilot Study, International Journal of Health Systems and Translational Medicine

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Effect of Yoga Therapy on Neuromuscular Function and Reduction of Autism Severity in Children With Autism Spectrum Disorder: A Pilot Study

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ABSTRACT

Autism is characterized by dysfunction in motor execution and sensory perception that are linked with neuromuscular function (fN) for children with autism spectrum disorder (ASD). This article aims to evaluate effectiveness of yoga therapy (YT) on fN and autism severity in children with ASD. Sixty children were screened (age 6 to 18) using childhood autism rating scale (CARS); 40 were allocated randomly (n=20) into yoga (YG) and control (CG) groups; both followed regular school routine, and YG received 10 YT sessions (60 min/session). Visual reaction time (VRT), handgrip strength (HGS), and CARS were measured. YG showed significant changes in VRT and CARS after YT and intergroup comparisons revealed significant differences between groups at the end of the study (VRT,p=0.008; CARS,p=0.011). YT resulted in small but statistically significant changes in CARS and significant improvement in VRT. This implies that YT can be used as an adjuvant modality for children with ASD, reducing co-morbidities with regard to the neuromuscular function.

KEYWORDS

Cognition, Integrated Yoga Therapy, Mindfulness-Based Practice, Neurodevelopmental Disorder

INTRODUCTION

Autism spectrum disorder (ASD) is a complex neurodevelopment disorder with estimated prevalence rate of 61.9/10,000 globally, 1% in the United Kingdom, 1.5% in the United States and it has been estimated that more than 2 million people may be affected with ASD in India (Chauhan et al., 2019). The core characteristics of ASD are impairments in cognition, communication, social-interaction,

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10.3. **Book chapter**: Yoga Therapy on Cognitive Function in Neurodevelopmental Disorders, Interdisciplinary Approaches to Altering Neurodevelopmental Disorders (indexed **PsycINFO**)

Chapter 9

Yoga Therapy on Cognitive Function in Neurodevelopmental Disorders

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ABSTRACT

Neurodevelopmental disorders (NDDs) are birth imperfections that cause dysfunction in cognitive and sensory processes and impairment in motor function, communication, and behavior. The major factors responsible for increasing incidence of NDDs are genetic, psychosocial, and excessive use of drugs. Yoga alleviates neurological problems and NDDs. Asana is a physical movement with breath awareness that facilitates the development of body awareness, concentration, and memory and provides vital energy for children with neurodevelopmental disability. Yoga therapy improves sensory coordination and motor imitations that enable persons with cognitive disabilities to make meaningful response by the integration of senses and functions of central nervous system.

INTRODUCTION

The global estimate for disability is raised due to increasing stress, chronic illness or chronic psychological distress in parents. World Health Organization estimates that 15% of the world's population live with some form of disability, of whom 2-4% experience significant difficulties in cognitive function (Suresh,

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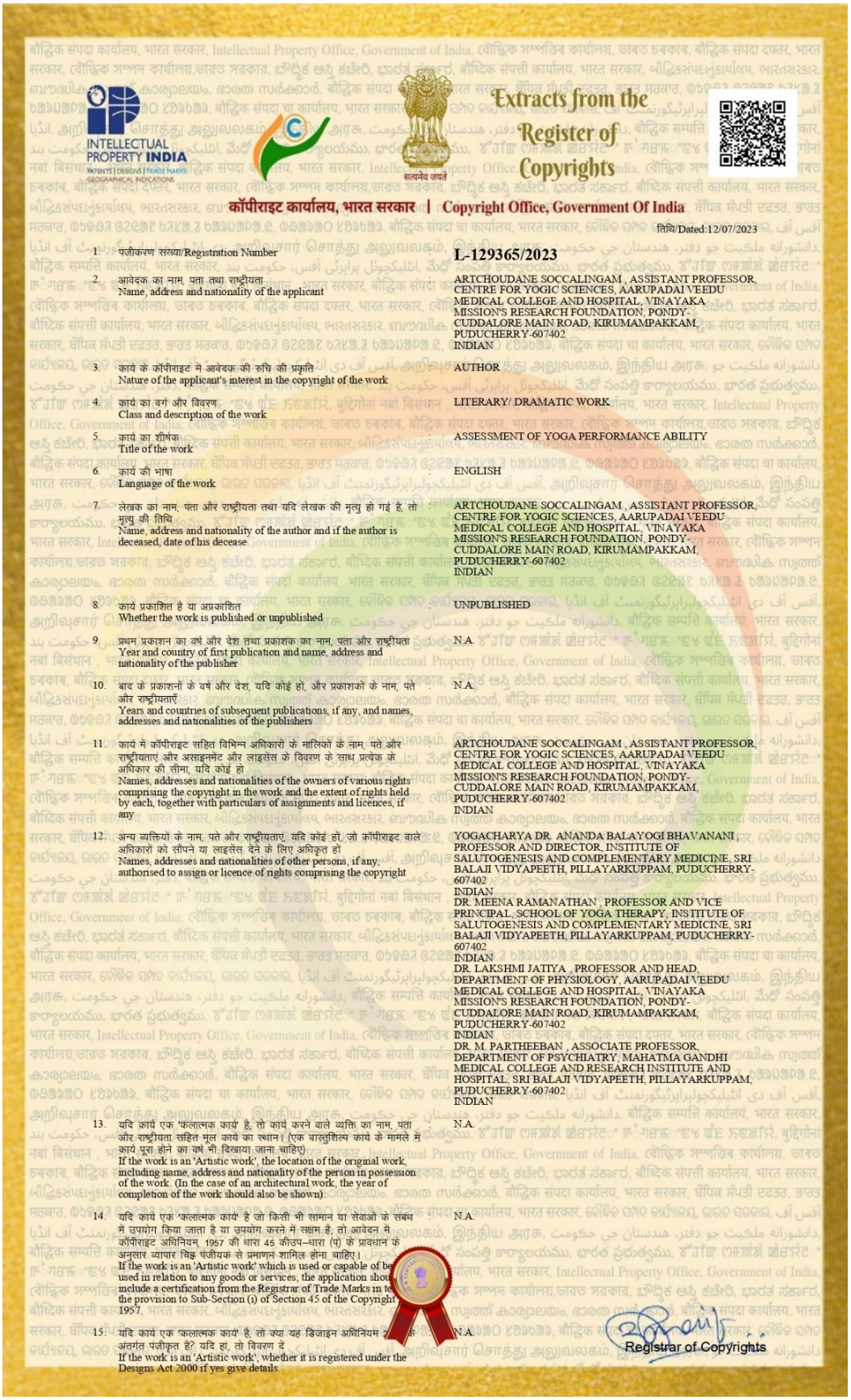

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